

Coastal Variability Analysis, Measurement, And Prediction (COVAMP)

Richard A. Paulus
SPAWARSYSCEN San Diego D858
49170 Propagation Path
San Diego, CA 92152-7385
phone (619) 553-1424 fax (619) 553-1417 email paulus@spawar.navy.mil

Dr. Douglas Jensen
SPAWARSYSCEN San Diego D858
49170 Propagation Path
San Diego, CA 92152-7385
phone (619) 553-1415 fax (619) 553-1417 email djensen@spawar.navy.mil

Dr. Kenneth L. Davidson
Naval Postgraduate School
Department of Meteorology Code MR/Ds
589 Dyer Road, Room 254
Monterey, CA 93943-5114
phone (831) 656-2309/2563 fax (831) 656-3061 email: davidson@nps.navy.mil

Kenneth D. Anderson
SPAWARSYSCEN San Diego D858
49170 Propagation Path
San Diego, CA 92152-7385
phone (619) 553-1420 fax (619) 553-1417 email: kenn@spawar.navy.mil

L. Ted Rogers
SPAWARSYSCEN San Diego D858
49170 Propagation Path
San Diego, CA 92152-7385
phone (619) 553-1413 fax (619) 553-1417 email: mailto:trogers@spawar.navy.mil

Document Number N0001499WX30125
<http://sunspot.spawar.navy.mil>

LONG TERM GOALS

The long-term goal is to provide representative three-dimensional, time-varying refractivity and optical property inputs for propagation models.

OBJECTIVES

The objectives are to provide a testbed to develop and evaluate urgently needed state-of-the-art measurement capabilities and accurate now- and forecasting techniques.

Report Documentation Page				Form Approved OMB No. 0704-0188	
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.					
1. REPORT DATE 30 SEP 1999		2. REPORT TYPE		3. DATES COVERED 00-00-1999 to 00-00-1999	
4. TITLE AND SUBTITLE Coastal Variability Analysis, Measurement, And Prediction (COVAMP)				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Space and Naval Warfare Systems Center, Code D858, 49170 Propagation Path, San Diego, CA, 92152				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT Same as Report (SAR)	18. NUMBER OF PAGES 8	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			

APPROACH

No one instrument or model is currently available with the capability to characterize propagation conditions on the necessary spatial and temporal scales thought to be typical of the coastal regions. Therefore, sensing information from a variety of sources/instruments are to be combined with high-resolution meteorological mesoscale models to provide a better description of the propagation environment than either sensing or models alone. COVAMP is divided into 4 tasks: (1) Electrooptical Propagation Assessment in Coastal Environments (EOPACE), (2) Remote Sensing, (3) Sensing of Atmospheric Refractivity (SOAR), and (4) Refractivity Test Bed. Tasks (3) and (4) were new starts in FY99.

WORK COMPLETED

EOPACE

Over the past five years nine EOPACE IOPs have been conducted within the coastal regions of the continental U.S. to determine the impact of coastal aerosols on electrooptical propagation in a coastal environment. Information concerning the EOPACE work plan is available on the internet EOPACE home page (<http://sunspot.spawar.navy.mil:80/543/eopace/eomain.html>). The ninth and final EOPACE IOP, the surf aerosol generation/transport effort at Duck, N.C. (21 February – 13 March 1999), was planned, conducted, and completed. This was a cooperative effort between the Army, NRL Washington and Monterey, SSC San Diego, DREV (Canada), University of Sunderland & DERA (UK), Polish Academy of Science (Poland), NPS, NASA (Goddard, Langley, & AMES), NCAR, TNO (Holland) and the Universities of Alabama & Oregon State. The database for all the IOPs has been reduced into the standard EOPACE format and made available to all EOPACE participants via the internet. The EOPACE database is also available to others via the ONR sponsors.

During FY99-01, the principle objective of EOPACE is to analyze the data base as per the objectives outlined by the EOPACE Scientific Committee and approved by the participants (see the EOPACE home page). An extensive effort has been made to make an initial evaluation/analysis of the database for publications and presentations at technical symposiums. To date, over 100 papers have been presented at technical symposia, published in open literature, or written as Masters/PhD theses. The symposia include SPIE, the NATO Research & Technology Organization RTO meetings, AGARD, The Battlespace Atmospheric and Cloud Impact on Military Operations Conferences, IGARSS, IRIS, The European Aerosol Conferences, and URSI. During FY99 an invited session on EOPACE was held at the European Aerosol Conference (EAC), 6-10 September, 1999, Prague, Czech Republic. Six papers were presented and will appear as extended abstracts in the *Journal of Aerosol Science*. In addition, an invited paper was presented at the LASE 2000 SPIE conference and is published in the proceedings. An invited paper on the EOPACE overview and accomplishments was given at the URSI XXVIth General Assembly '99. All of these publications/papers are listed on the EOPACE home page. Eight papers have been accepted for open literature reviewed publications.

REMOTE SENSING

In the GPS Sounder project, the Wallops Island data from March 1998 were reprocessed using the fully automatic correlation process developed last year. A paper entitled "Determination of Water Level and Tides Using Interferometric Observations of GPS Signals" was accepted for publication by the *Journal of Atmospheric and Oceanic Technology*. This paper documents the correlation process for extracting

antenna height above water using data collected at Scripps Pier, which are calibrated to survey benchmarks and the local tide gauge, and data from the 1998 Wallops Island experiment. A paper entitled "Detection of Tropospheric Ducts Using a Ground-Based GPS Receiver" was presented at the 1999 meeting of the International Union of Geophysics and Geodesy (IUGG), Birmingham, UK (July).

SENSING OF ATMOSPHERIC REFRACTIVITY

SOAR is a new start in FY99. We procured and repaired instruments and equipment in preparation for propagation experiments. Propagation measurements were conducted at Wallops Island, VA on the SPY-1 radar at the AEGIS Combat System Center as a preliminary test of our ability to measure SPY-1 signals during USS O'KANE CSSQT at Pacific Missile Range Facility, HI in November and December 1999 in support of the Tactical Environmental Processor (TEP) testing.

REFRACTIVITY TEST BED

Penn State performed a detailed review of the spectral PBL coding, line by line. This review has uncovered a number of important inconsistencies that will be corrected in the next several months. The coding errors are of a type that did not seriously affect model performance in the marine environment (flat surface), but will have a potentially large impact over complex terrain. This is very significant because prior applications of the spectral PBL model indicated stability problems in mountainous regions. Next, a new experiment with the PSU/NCAR MM5 is under way for an eight-day period during VOCAR (Variability of Coastal Atmospheric Refractivity – an ONR project investigating VHF/UHF propagation and meteorological modeling in the southern California coastal region completed in 1996). The new experiment replaces the original Blackadar PBL model with the Penn State 1.5-order turbulent kinetic energy (TKE) PBL scheme. When this experiment is completed (4-km resolution), it will enable us to perform tests with the Refractivity Test Bed to learn the sensitivity of propagation loss estimates (made with a parabolic equation model) to alternative mesoscale boundary-layer physics. This work will be at the foundation of a future ensemble for propagation studies. A third area of work is the construction of a cross-section extractor code that is compatible with the MM5 version 2 structure. This work, now nearing completion, will enable a user to easily extract refractivity from any MM5v2 output along arbitrarily oriented cross sections and with any prescribed resolution. This is another fundamental component of a functioning RTB. Two conference papers for the 3rd AMS Conf. on Coastal Atmospheric and Ocean Predictions and Processes are being prepared to describe aspects of the work.

RESULTS

EOPACE

As a result of the EOPACE effort and the initial analysis of the extended database, the following accomplishments have been made and reported on. They are: 1) developed an aerosol-size-distribution model as a function of swell height, 2) characterized the plume structure and transport of surf generated aerosols, 3) measured and modeled the near surface transmission effects (aerosols, molecular extinction, and refraction), 4) developed direct and remote sensing techniques for describing the scaling parameters for background aerosols (AMP), 5) demonstrated the capability and limitations of bulk methods to predict scintillation effects, and 6) produced over one hundred papers, presentations, publications, MS and Ph.D. theses from the analysis of the EOPACE database.

NRL RHI Lidar Return

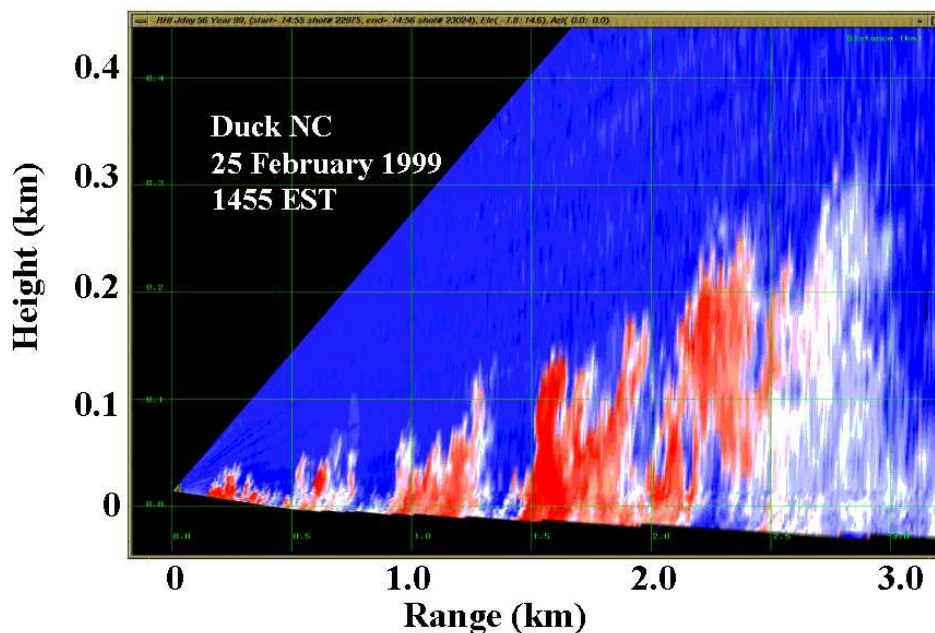


Figure 1. NRL RHI Lidar Return, Duck NC 25 February 1999.

Figure 1 is an example of the surf generated plume structure as seen by the NRL lidar at Duck NC, (IOP#9). Plumes generated on the surf line (zero range) are transported horizontally (to ranges greater than 3 km) and vertically (to heights exceeding 300 meters) as a result of the offshore wind component.

REMOTE SENSING

Results from the analysis of the reprocessed data from the Wallops'98 experiment were reported at the National Radio Science meeting held in Boulder, CO in January 1999. The results are excellent when compared to both the time consuming peak-extraction technique that was used previously and 'truth' data consisting of independent tide-gauge and local leveling measurements. The correlation process has been extended to infer profiles from the measured GPS data. Two days of observations during strong surface ducting conditions have been analyzed using this technique and the results are excellent indicating that the correlation process is a viable method to infer the refractive profile from GPS measurements.

IMPACT/APPLICATIONS

The spatial and temporal data collected under this project are used to validate system performance models and provide variability statistics to EM/EO system designers. The EOPACE effort has resulted in quantifying the effects of aerosols in the variable coastal regime and, in particular, the effects of surf-generated aerosol on IR transmission within this coastal environment. EOPACE results are impacting the scientific community through invited EOPACE sessions in the NATO Sensors and Electronics Technology Panel Symposia, SPIE Symposia on "Propagation and Imaging Through the Atmosphere," the EAC European Aerosol Conference, invited papers at the LASE 2000 SPIE and URSI

GA '99 Symposia, and presentations at technical symposium such as AGARD, the BAC/BACIMO (Battlespace Atmospheric Conferences/Battlespace Atmospherics and Cloud Impact on Military Operations), IGARSS, IRIS, and organizational technical reports.

TRANSITIONS

EOPACE field experiments have provided a rich database for analysis of propagation effects, subsequent model development, and validation. Results from the GPS Sounder task have prompted an investigator from the University of Bath, Bath, UK to attempt to repeat these measurements to confirm how well tropospheric ducts can be detected.

RELATED PROJECTS

This project is closely related to the synoptic and mesoscale numerical analysis and prediction projects pursued by NRL Monterey, the EM Propagation and EO Propagation projects, and the Remote Refractivity Sensing project under ONR 321SI. Tri- service coordination is conducted under the Technology Area Review and Assessment.

PUBLICATIONS

EOPACE

Davidson, K.L, and C.H. Wash, "Describing Coastal Optical Properties with in situ and Remote Measurements," Naval Research Reviews, Office of Naval Research Two/1998, Vol L, pp. 2-7, 1998.

Nener, B.D., T.A. Ridsdill-Smith, and C.R. Zeisse, "Wavelet Analysis of Low Altitude Infrared Transmission in the Coastal Environment," *Infrared Physics and Technology* (Elsevier), 1999 (in press).

Jordan, M.S., C.H. Wash, P.A. Durkee, P. Veefkind, G. de Leeuw, M.H. Smith and M.K. Hill, "Satellite and Ship-based Lidar Measurements of Optical Depth during EOPACE," Proceedings of the IEEE 1998 International Geoscience and Remote Sensing Symposium (IGARSS), Seattle, WA, 6-10 July 1998.

Frederickson, P.A., K.L. Davidson, C.R. Zeisse, and C.S. Bendal, "Estimating Near-Surface Scintillation (C_n^2) for Overwater Littoral Paths," Proceedings of the Battlespace Atmospherics and Cloud Impacts on Military Operations (BACIMO) Conference, Hanscom AFB, MA, 1-3 December 1998.

Wash, C.H., M.S. Jordan, P.A. Durkee, P. Veefkind, G. de Leeuw, M.H. Smith and M.K. Hill, "Satellite Estimate of Optical Depth during EOPACE," Proceedings of the Battlespace Atmospherics and Cloud Impacts on Military Operations (BACIMO) Conference, Nanscom AFB, MA, 1-3 December 1998.

Zeisse, C.R., B.D. Nener, and R.V. Dewees, "Measurement of Low-Altitude Infrared Transmission," SSC San Diego Technical Report 1797, April 1999.

Frederickson, P.A., K.L. Davidson, C.R. Zeisse, C.S. Bental, "Estimating the Refractive Index Structure Parameter (C_n^2) Over the Ocean Using Bulk Methods," submitted to *Journal of Applied Meteorology*, June 1999.

Hughes, H.G., and C.R. Zeisse, "Infrared Propagation Modeling Beneath Marine Stratus Clouds", accepted for publication in the *Journal of Atmospheric and Oceanic Technology*, June 1999.

Frederickson, P.A., K.L. Davidson, C.R. Zeisse, and C.S. Bental, "Near-Surface Scintillation Over the Ocean," SPIE Proceedings of the Conference on Propagation and Imaging through the Atmosphere III, Vol. 3763, Denver, CO, 22-23 July 1999.

Jensen, D.R., C.R. Zeisse, and K.M. Littfin, "EOPACE (Electrooptical Propagation Assessment in Coastal Environments) Overview and Initial Accomplishments," XXVIth General Assembly of the International Union of Radio Science (URSI), August 13-21, 1999, Toronto, Ontario, Canada, 1999.

Littfin, K.M., and S.G. Gathman, "Effects of Large Aerosol on Infrared Propagation over the Ocean," XXVIth General Assembly of the International Union of Radio Science (URSI), August 13-21, 1999, Toronto, Ontario, Canada, 1999.

Vignati, E., G. de Leeuw, W.P. Hooper and S.G. Gathman, "Aerosol Plumes produced over the Surf Zone," 1999 European Aerosol Conference, Prague, CZ, 6-10 September 1999, in press (*Journal of Aerosol Science*).

Van Eijk, A.M.J., G. de Leeuw and S.G. Gathman, "The Vertical Distribution of Large Aerosols in the Marine Atmospheric Surface Layer," 1999 European Aerosol Conference, Prague, CZ, 6-10 September 1999, in press (*Journal of Aerosol Science*).

Jensen, D.R., S.G. Gathman, C.R. Zeisse, and K.M. Littfin, "EOPACE (Electrooptical Propagation Assessment in Coastal Environments) Overview and Initial Accomplishment," 1999 European Aerosol Conference, Prague, CZ, 6-10 September 1999, in press (*Journal of Aerosol Science*).

Littfin, K.M. and S.G. Gathman, "Characterizing Background Aerosol in an Air Mass: A Comparison of Three Methods," 1999 European Aerosol Conference, Prague, CZ, 6-10 September 1999, in press (*Journal of Aerosol Science*).

Zeisse, C.R., S.G. Gathman, D.R. Jensen, K.M. Littfin, W.K. Moision, and B.D. Nener, "Marine Aerosol Particles and Infrared Transmission," 1999 European Aerosol Conference, Prague, CZ, 6-10 September 1999, in press (*Journal of Aerosol Science*).

Nener, B.D., T.A. Ridsdill-Smith, C.R. Zeisse, S.G. Gathman, and D.R. Jensen, "Marine Aerosol, Humidity, and Midwave Infrared Transmission," 1999 European Aerosol Conference, Prague, CZ, 6-10 September 1999, in press (*Journal of Aerosol Science*).

Frederickson, P.A. and K.L. Davidson, "Measurement and Modeling of Near-Ocean Surface Properties Affecting Aerosol Concentration Profiles during EOPACE," 1999 European Aerosol Conference, Prague, CZ, 6-10 September 1999, in press (*Journal of Aerosol Science*).

Zeisse, C.R., C.P. McGrath, K.M. Littfin, and H.G. Hughes, "Infrared Radiance of the Wind-Ruffled Sea," *Journal of the Optical Society of America A*16, 1439-1452 (1999).

Zeisse, C.R., B.D. Nener, and R.V. Dewees, "Measurement of Low Altitude Infrared Transmission," accepted for publication with minor revisions in *Applied Optics*.

Reid, J.S., and H.K. Jonsson, "Evolution of the Vertical Profile and Flux of Large Sea-Salt Particles in a Coastal Zone," submitted to *Geophys. Res. Lett.*, September 1999.

Gathman, S.G., "The Marine Aerosol Effects on Infrared Propagation over the World's Ocean," accepted for publication in *Oceanologia*, September 1999.

The following publications have been authored by EOPACE collaborators using data collected during IOPs:

Forand, J. L. and D. Dion, "DREV and the EO Propagation Assessment in Coastal Environments (EOPACE) Trial," DREV TM-9817, October 1998.

Nener, B. D., S. Ng, and N. Fowkes, "Effects of Atmospheric Refractivity on the Infrared Propagation at Low Altitudes over the Ocean," 13th National Congress of the Australian Institute of Physics, July 1998.

Neele, F.P., G. de Leeuw, M. Jansen, M. Stive and M.H. Smith, "Aerosol Production in the Surf Zone," *J. Aerosol Sci.* 29, Suppl.1, pp. S181-S182, 1998.

Vignati, E., R. Berkowics, and G. de Leeuw, "Transport of aerosols and their interaction with gases in the coastal environment," 6th FECS Conference on Chemistry and the Environment: Atmospheric Chemistry and Air Pollution, Copenhagen, August 26-28, 1998: *ESPR-Environ. & Pollut. Res.* 5(3), 196.

De Leeuw, G., "Sea Spray Production from Waves Breaking in the Surf Zone," 1999 European Aerosol Conference, Prague, CZ, 6-10 September 1999, in press (*Journal of Aerosol Science*).

De Leeuw, G., F.P. Neele, M. Hill, M.H. Smith, and E. Vignati, "Sea Spray Aerosol Production by Waves Breaking in the Surf Zone," in preparation for submission to *JGR*, 1999.

Neele, F. P., G. de Leeuw, M. Jansen, and M. Stive, "Modeling production of Sea Spray Aerosol by Waves Breaking in the Surf Zone," in preparation for submission to *JPO*, 1999.

Vignati, E., G. de Leeuw, and R. Berkowicz, "Transport of Aerosols and their Interaction with Gases in the Coastal Environment," EGS 24th General Assembly, Geophysical Research Abstracts, Volume 1, Number 2, The Hague (NL), 1999.

REMOTE SENSING

Anderson, K.D., "Detection of tropospheric ducts using a ground-based GPS receiver," XXII General Assembly of the International Union of Geodesy and Geophysics, 18-30 July 1999, University of Birmingham, Birmingham, UK

Anderson, K.D., "Determination of Water Level and Tides Using Interferometric Observations of GPS Signals," accepted by the *Journal of Atmospheric and Oceanic Technology*, August 1999.

Gossard, E.E., S. Gutman, B.B. Stankov, and D.E. Wolfe, "Profiles of radio refractive index and humidity derived from radar wind profilers and the Global Positioning System," *Radio Science*, 34(2), pp. 371-383, April 1999.

REFRACTIVITY TEST BED

Stauffer, D.R. and N.L. Seaman, "Intercomparison of Turbulence Parameterizations for Simulating Coastal-Zone Marine Boundary Layer Structure," 3rd Conf. on Coastal Atmospheres and Ocean Predictions and Processes, AMS, New Orleans, LA, Nov. 3-5, 6 pp., 1999